

BIOL 203

Microorganisms and Food Production

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A microorganism is a microscopic organism that is either unicellular, or composed of cell clusters. This includes organisms such as bacteria, fungi, and yeast. Microorganisms are found everywhere in the world and in all living things. While some microorganisms can be harmful, and may tend to give others a bad name, there are plenty of microorganisms that are very beneficial and can be put to good use. One example of this is the use of microorganisms in food and beverage production. Microorganisms have been used in the production of certain foods for thousands of years now. They are used in many processes including brewing, winemaking, baking, pickling, as well as the fermentation of dairy and other products.

One of the oldest food production technologies known is fermentation. Records of this process have been dated as far back as 6000 B.C. Fermentation is defined as the microbial degradation of organic compounds without net oxidation. (Sieuwerdt, de Bok, Hugenholtz, & van Hylckama Vlieg, 2008) It can provide many benefits to foods such as allowing them to last longer, enhancing flavors, textures, and aromas, and also provides health benefits such as superior digestibility.

The goal of fermentation in food preservation is to produce end products which are usually acids, alcohol, and carbon dioxide. These are generated by the oxidation of carbohydrates and other derivatives. The end products control the growth of microorganisms that can cause food spoilage, and since the oxidation is only partial, the food keeps sufficient energy potential to provide nutrient benefits to the consumer who eats it. (Caplice & Fitzgerald, 1999) Most fermented foods are dependent on lactic acid bacteria to mediate the fermentation process. The end products of carbohydrate catabolism of these bacteria help to create unique characteristics in products such as texture, flavor, and aroma, in addition to preservation.

Different types of microorganisms are used in the production of different types of foods. Many dairy products are made as a result of the fermentation of certain microorganisms found in milk and the products of milk. Buttermilk is made as the result of the souring of low fat milk by lactic acid. Buttermilk's unique flavor comes from substances such as diacetyl and acetaldehyde. These are produced by different species of *Streptococcus*, *Leuconostoc*, and *Lactobacillus* as they grow.

Fermentation is absolutely essential to the production of yogurt. *Streptococcus thermophilus* and *Lactobacillus bulgaricus* are added to milk after it has been heated to achieve evaporation. This condensed milk is set aside at room temperature and the yogurt is formed. (CliffsNotes, 2012) The function of the bacteria added to the yogurt is to ferment the lactose, which is the sugar in the milk, to produce lactic acid. The increase in lactic acid decreases the pH of the substance and causes the milk to clot during the process, which forms the pudding like consistency that yogurt has. *Streptococcus thermophilus* and *Lactobacillus bulgaricus* are the only two cultures that are required by law to be present in all yogurts, however other strains, such as *Lactobacillus acidophilus*, *lactobacillus subsp. Casei*, and Bifido-bacteria may be added to yogurt as probiotic cultures. These probiotics offer many benefits to human health which include improving digestion, gastrointestinal function, and stimulating the immune system. (Cornell, 2006) Sour cream is produced in a similar way to yogurt, but using cream as a starter material, instead of milk.

In addition to dairy products, other foods such as sauerkraut and pickles are produced through fermentation. Sauerkraut is made through lacto-fermentation of cabbage and goes through a process of three different stages to be produced. In the first stage, anaerobic bacteria such as *Klebsiella* and *Enterobacter* begin the fermentation by producing an acidic environment

which will favor later bacteria in the process. As acidic levels become too high for certain bacteria, killing them off, and *Leuconostoc* spp. take dominance because they are able to survive. This is followed by the third stage of the process, in which various *Lactobacillus* species ferment any remaining sugars, bringing the pH down further. When sauerkraut is properly cured, the acidic conditions prevent the growth of *Clostridium botulinum*, which causes botulism. (Battcock & Azam-Ali, 1998) The process of fermenting sauerkraut may take several months to complete. The making of pickles is a similar process; however the cucumbers used only take about a week to completely ferment into pickles.

Bacteria are not the only microorganisms that take part in the production of foods. Believe it or not, fungi can play a big role in food production as well. One type of food that fungi help to produce is bread. The fungi used in bread making are actually the yeast. The yeast that is used most often in the baking of bread is *Saccharomyces cerevisiae*. This yeast ferments the carbohydrates in the dough to produce carbon dioxide. (CliffsNotes, 2012) In this process, warm water brings the yeast cells to action. They begin to eat and digest the sugars in the bread and flour, which is when the carbon dioxide and small amounts of ethanol alcohol is released. The carbon dioxide produced causes the dough to rise when the bubbles become trapped in the bread dough, and creates the bread's soft texture. The yeast normally needs a few hours for this process to occur in order to sufficiently cause the dough to rise.

Many different types of microorganisms are used in the making of cheese, depending on which type of cheese is being made. Milk is the main ingredient found in cheese. It may be the milk of cows, goats, sheep, or other animals, or possibly a blend of different types of milk, and can be milk of any fat content, from whole to skim. Cultures used in cheese making are lactic acid bacteria. Their primary source of energy is the lactose sugar found in the milk and their

primary metabolic product is lactic acid. The starter cultures used in the cheese making process assist with the coagulation of the milk by lowering the pH prior to the addition of rennet, which is a complex of enzymes that is found in the stomach of mammals. The metabolism of the starter cultures result in desirable flavor compounds and help to prevent the growth of organisms or pathogens that may contribute to spoilage. There are multiple different typical starter bacteria. These include *Lactococcus lactis* subsp. *lactis* or *cremoris*, *Streptococcus salivarius* subsp. *thermophilus*, *Lactobacillus delbruckii* subsp. *bulgaricus*, and *Lactobacillus helveticus*. In addition to starter cultures, adjunct cultures are used to provide or enhance the cheese's characteristic flavors and textures. The flavor of Cheddar cheese comes from adjunct cultures *Lactobacillus casei* and *Lactobacillus plantarum*. The eye formation in Swiss cheese is assisted by adjunct culture *Propionibacterium freudenreichi*. Adjunct cultures are also used as a smear for washing the outside of some formed cheeses. An example of this would be the use of *Brevibacterium linens* for gruyere, brick, and limburger cheeses. (Cornell, Cheese Production, 2006)

In addition to bacteria, yeasts and molds are used to create characteristic colors and flavors of certain cheeses as well. Torula yeast is used as part of a smear to ripen brick and limburger cheeses. Some molds that are used are *Penicillium camemberti* in camembert and brie cheeses, as well as *Penicillium roqueforti* in blue cheeses. (Cornell, Cheese Production, 2006) The mold spores may be injected into the cheese either during, or after the cheese making process, depending on the type of cheese.

Besides being a part of bread and cheese making, yeast is also used in the production of beer and other alcoholic beverages. Depending on the type of beer, different yeast may be used for different purposes and the process of making the beer is slightly different. For instance, the

type of yeast used to make lager beers is *Saccharomyces cerevisiae*. In the process of making lager beer, fermented barley releases starches and amylase enzymes in a process called malting. The enzymes in the malt hydrolyze starch to fermentable sugar in the mashing process. The liquid produced (known as wort) is sterilized. Hops and yeast are then added. The beer is incubated at 3-10 degrees Celsius (or 10-21 degrees Celsius for steam beers), and wort is added for a secondary fermentation. The purpose of the yeast in this process is to convert the sugar into alcohol and carbon dioxide. It can produce more than 6% alcohol. In the case of lager beers, the yeast grows in the bottom of the fermentation vessel. In ale beers, the yeast used is also *Saccharomyces cerevisiae*, however this yeast grows at the top of the fermentation vessel. They are produced almost the same as lager beers, except sugar is added to the beer for secondary fermentation. The yeast produces less than 4% alcohol. Lambic beers use wild yeasts which can include *Kloeckera apiculata*, *Brettanomyces lambicus*, or *Saccharomyces cerevisiae*. The yeast converts sugar into alcohol and carbon dioxide, as well as organic acids and esters. Just as in ale, less than 4% alcohol is produced. Sake is an alcoholic beverage of Japanese origin. It starts out with steamed rice, while *Aspergillus oryzae* converts into sugar. Yeast (*Saccharomyces cerevisiae*) is then added and it is incubated at 20 degrees Celsius. The function of the yeast is to convert sugar into alcohol. Sake contains much more alcohol than many other alcoholic beverages, at 14-16% alcohol. Initially, the yeast in these alcoholic beverages grows quickly under aerobic respiration. However, the oxygen eventually gets depleted, which is when the yeast switches to fermentation to produce ethyl alcohol. (Case, 2012)

Despite the fact that some microorganisms can do a lot of damage to our foods to spoil them, there are so many other helpful microorganisms that go into producing many of the foods that we love and eat every day. The foods mentioned above are not the only foods produced

through the use of microorganisms either. Other foods that are made using microorganisms include coffee, chocolate, soy sauce, olives, meat products such as salami and bologna, and also certain food additives such as MSG and citric acid. The truth is that microorganisms really are a huge part of our diets.

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